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**UNIVERSITI SAINS MALAYSIA**

1<sup>st</sup> Semester Examination  
2010/2011 Academic Session

November 2010

**EAS 661/4 – Advanced Structural Mechanics**

Duration :    hours

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Please check that this examination paper consists of..... printed pages before you begin the examination.

[Instructions: This paper contains **FIVE (5)** questions. Answer \_\_\_\_ (\_\_\_\_) questions only.

You must answer the questions in English.

All question **MUST BE** answered on a new sheet.

1. Dr Choong

(20 marks)

2. Dr. Choong

(20 marks)

3. Dr Choong

(20 marks)

(Dr Neeraj) Question 1: a) In continuum mechanics, contravariant and covariant tensor are frequently used, so what is the difference between these two tensors. If a contravariant tensor is defined by  $S = a_{\alpha\beta\gamma} x^\alpha x^\beta x^\gamma = 0$ , then evaluate  $\frac{\partial^3 S}{\partial x^\alpha \partial x^\beta \partial x^\gamma}$ .

b) A covariant tensor has components a, b, c in rectangular Cartesian co-ordinates, find the components in spherical co-ordinates.

5. (a) Briefly define the difference between a triangular and rectangular finite element in plane elasticity.

( 5 marks)

5. (b) Show clearly in a step by step manner the development process of a stiffness matrix,  $[K]^e$ , for a triangular element in a state of plane stress as shown in Figure 5. Given  $E = 200 \text{ GN/m}^2$ ,  $\nu = 0.3$  and  $t = 1 \text{ cm}$ .

( 15 marks)

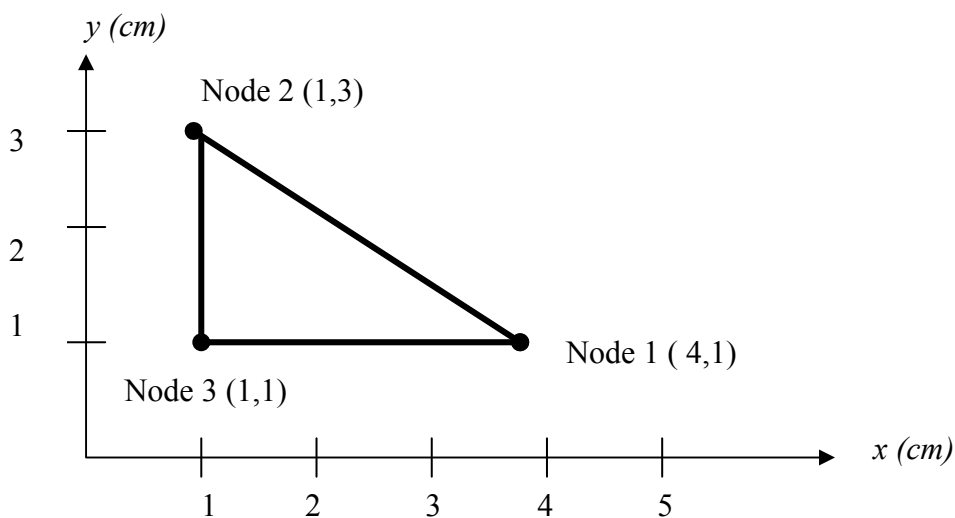


Figure 5

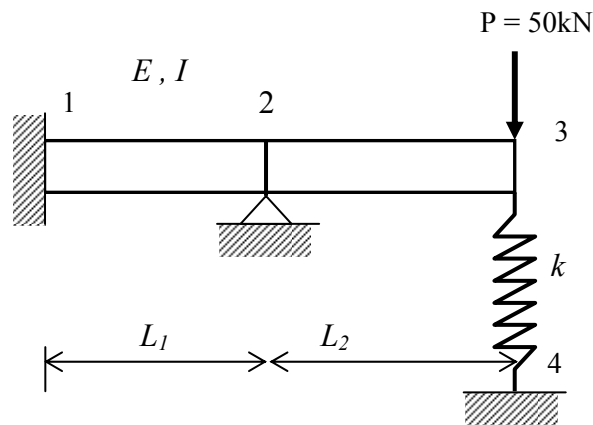
6. (a) Clearly define the difference between a bar and beam in the analysis using finite element Method.

( 5 marks)

(c) Figure 6 shows a system of two beams labeled with node 1,2 and 3 and a spring labeled with node 3 and 4 subjected to a nodal forces of  $P = 50 \text{ kN}$  at node 3. The beam is fixed at node 1, simply supported at node 2 and spring support at node 3. The spring system can only displace in axial direction and is supported at node 4. Given the value of  $k = 200 \text{ kN/m}$ ,  $L_1 = L_2 = 3\text{m}$ ,  $E = 210\text{GPa}$  and  $I = 2 \times 10^{-4} \text{ m}^4$ .

- Obtain the element stiffness matrix for the beam and the spring.
- Derive the global stiffness matrix for the system.
- Evaluate the deflection  $v_3$ ,  $\theta_2$  and  $\theta_3$  in unit metre and rad respectively.

(15 marks)



**Figure 6**

**Given the stiffness of the beam element in dimensional space:**

$$k = \frac{EI}{L^3} \begin{bmatrix} v_i & \theta_i & v_j & \theta_j \\ 12 & 6L & -12 & 6L \\ 6L & 4L^2 & -6L & 2L^2 \\ -12 & -6L & 12 & -6L \\ 6L & 2L^2 & -6L & 4L^2 \end{bmatrix} \text{ for the beam element}$$